

TASK STATUS REPORT

TASK 1.1 - PI, INSTITUTION: Vincent Battaglia, Lawrence Berkeley National Laboratory

TASK TITLE - PROJECT: Cell Analysis - Cell Fabrication and Materials Characterization

SYSTEMS: High-voltage, high-energy: Gr/1 M LiPF₆ in EC:DEC (1:2)/LiNi_{1/3}Mn_{1/3}Co_{1/3}O₂

BARRIERS: High energy system: low energy, poor cycle life

OBJECTIVES: 1) Bring fundamental understanding to electrode and cell construction. 2) Provide a comprehensive, independent assessment of promising materials with regard to meeting high-power or high-energy performance and cycling requirements, and differentiate between material and cell failure.

GENERAL APPROACH: Objective 1) is achieved through engineering design analysis of each of the steps of the electrode fabrication process and determining why certain configurations of binder and conductive additive work better for a given active material. Objective 2) is achieved through the identification and application of key diagnostic techniques that allow for the physical, chemical, thermal, and electrochemical characterization of materials as they relate to battery performance for advanced transportation applications.

STATUS OCT. 1, 2009: Correlations between electrode cyclability and mechanical strength are being developed. A new binder was synthesized for using Si nanoparticles as an anode: electrodes cycled at C/10 have shown a capacity of 2000 mAh/g for 150 cycles with little to no power fade after 40 cycles. A graphite has been selected as the new baseline, replacing MCMB. A new, high-voltage electrolyte showed improved coulombic efficiency when cycled in Li/NCM cells using cut-off voltages from 4.1 to 4.5 V. It was determined that VC has no measurable effect on the coulombic cycling efficiency of a graphite electrode.

EXPECTED STATUS SEP. 30, 2010: Correlation of electrode mechanical properties to cyclability will be established. The source of self discharge will be identified. We will know the extent to which the oxidation of the electrolyte is cathode material dependent. We will know the fundamental advantages and disadvantages of SBR binder.

RELEVANT USABC GOALS: PHEV-40: 144 Wh/l, 4000 deep-discharge cycles.

MILESTONES:

- (a) Report the coulombic efficiency of baseline NCM vs. graphite and vs. a lithium counterelectrode. (Jan. 10) **Complete**
- (b) Report performance characteristics of a SBR-CMC-binder based anode. (Mar. 10) **Complete**
- (c) Distribute electrodes cycled to different cut-off voltages to other members of the BATT program. (Apr. 10) **On schedule**
- (d) Report the results of the mechanical properties vs. cycling capability of NCM-PVdF-based cells. (Sep. 10) **On schedule**

PROGRESS TOWARD MILESTONES

(a) Report the coulombic efficiency of baseline NCM vs. graphite and vs. a lithium counterelectrode. (Jan. 10) **Complete**. See 2nd Quarter Report.

(b) Report performance characteristics of a SBR-CMC-binder based anode. (Mar. 10) **Complete**. See 1st Quarter Report.

(c) Distribute electrodes cycled to different cut-off voltages to other members of the BATT program. (Apr. 10) **Complete**. Work with Kostecki Group has begun. We are providing cycled and uncycled laminates to one of his post-docs.

(d) Report the results of the mechanical properties vs. cycling capability of NCM-PVdF-based cells. (Sep. 10) **Complete**. We found that depending on the mixing order, the laminates cast resulted in different physical properties. With this knowledge we could make electrodes of the same composition but with various Young's modulus. The focus of this work was the anode as the anode experiences the greater amount of expansion and contraction with cycling. Full cells of Graphite/NCM of different elastic modulus were cycled. The cells of lesser stiffness *i.e.* smaller Young's modulus, cycled longer than the cells with the higher modulus. What is not clear is whether this is a function of the mechanical properties of the laminate or a function of the degree of mixing on a sub 40-micron level. This data was presented at the DOE AMR June meeting, poster #es081p.

Other work. We are also investigating the rate of the side reaction/s on the anode. This quarter we measured the effect of changing the counter electrode against which the anode was cycled and also the effect of adding VC to a full. To do this experiment we used a cell with a reference electrode and a counter electrode with more capacity for Li ions than the anode. The anode was cycled *versus* the reference electrode. In one case, the opposite electrode was lithium metal (this was also repeated) and in two other cases the opposite electrode was NCA. In one of the NCA cells, VC was added to the electrolyte at a 2% concentration. Plotted in Figure 1 is the capacity shift per cycle *versus* the cycle number. The capacity shift is the difference in capacity measured on charge and discharge divided by the discharge capacity. The graphite used for this study was SNG12 from HydroQuebec because it shows limited passivation characteristics. For the cell with lithium as the counter electrode, the capacity shift after 10 cycles was between 0.4 and 0.9 % per cycle. When the lithium was replaced with NCA as the counter electrode, the capacity shift increased to around 2.3% per cycle. Addition of VC reduced the capacity shift of the anode back to where it was when lithium metal was the counter electrode. The effect of this change in side reaction for the anode on the full cell cycleability is still under investigation.

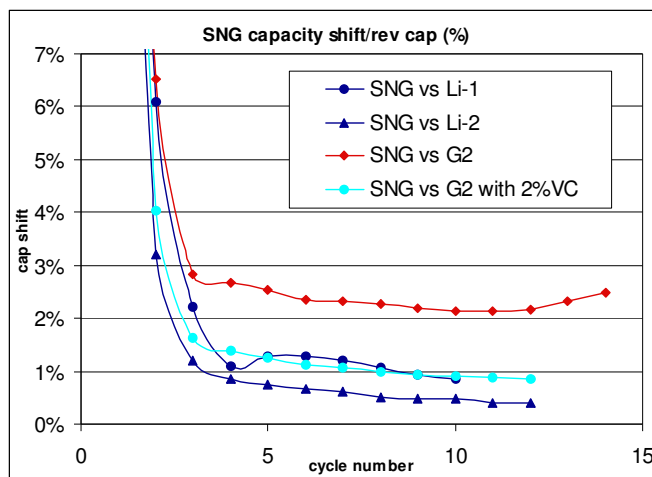


Figure 1. Capacity shift versus cycle number for four cells: two cells contain Li as the counter electrode, one cell contains NCA, and the fourth cell contains NCA and VC.